A Recipe for Swank's Coefficients with CsI Scintillator*

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CsI is an attractive scintillator for medical x-ray imaging. It is bright, fast, color matched to silicon detection response and can be grown with columnar microstructure that limits the spread of the light produced. Understanding and predicting performance of systems that integrate light pulses from CsI scintillator requires accounting for the absorbed energy distribution. Swank 1 published coefficients that enable this accounting for discrete x-ray energies and for a few specific scintillator thicknesses. We present here a method for interpolation of Swank's data to permit analysis of x-ray spectra containing x-rays up to 50 keV and for CsI with thickness from 111 to 443 μ m. This covers the ranges of interest for digital mammography. These formulas reproduce Swank's published values for A_N (E,t)/ A_Q (E,t) and A_E (E,t)/ A_Q (E,t) with a maximum error of 1.04% within the specified ranges of energy and thickness.

Using Swank's notation

 A_O (E,t)= quantum absorption,

number of detected photons per incident photon

 A_N (E,t)= fractional energy absorption

 A_E (E,t)= noise equivalent absorption

where E and t denote x-ray energy (keV) and CsI thickness (μm).

$\mathbf{A}_{o}(\mathbf{E},\mathbf{t})$

The quantum absorption, $\mathbf{A}_{\mathcal{Q}}$ (E,t) , is easily computed from the total cross sections 2 of Cs and I.

$\mathbf{A}_{N}\left(\mathbf{E},\mathbf{t}\right)$

Energy below 33.17 keV

$$A_N$$
 (E,t) = A_O (E,t)

Energy $33.17 \le E \le 35.98 \text{ keV}$

$$A_N (E,t) = A_Q (E,t) \{ -1.2238 + 0.04466 E + [0.67441 - 0.013566 E] \log_{10} (t) \}$$

Energy greater than 35.98 keV

$$A_N (E,t) = A_Q (E,t) \left\{ -2.285 + 0.09945 E -0.0008156 E^2 + \left[0.8162 - 0.02231 E + 0.0001607 E^2 \right] \log_{10}(t) \right\}$$

\mathbf{A}_{E} (E,t)

Energy below 33.17 keV

$$A_E(E,t) = A_O(E,t)$$

Energy $33.17 \le E \le 35.98 \text{ keV}$

$$A_E(E,t) = A_O(E,t) \{ -0.57602 + 0.021893 E + [0.45793 - 0.006032 E] \log_{10}(t) \}$$

Energy greater than 35.98 keV

$$A_{E}(E,t) = A_{Q}(E,t) \left\{ -0.9126 + 0.03509 \text{ E} -0.0002207 \text{ E}^{2} + \left[0.4888 - 0.007244 \text{ E} + 3.684 \text{ x } 10^{-5} \text{ E}^{2} \right] \log_{10}(t) \right\}$$

The quality of fit to Swank's values for $A_N(E,t)/A_Q(E,t)$ is illustrated in Figure 1. Similar quality is obtained for $A_E(E,t)$.

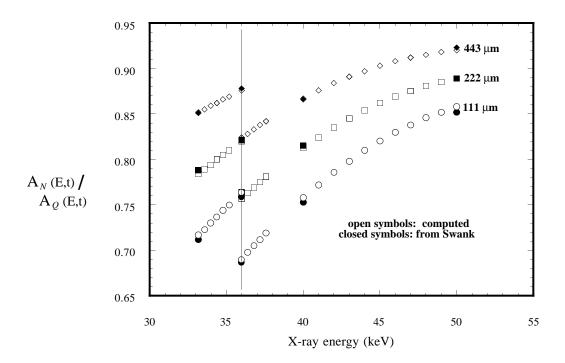


Figure 1. Illustration of the quality of fit for $A_N(E,t)/A_Q(E,t)$ using our recipe.

References

- 1. Robert K. Swank, *Absorption and Noise in X-ray Phosphors*, J. Appl. Phys., **44#9** 4199-4203.
- 2. D.E. Cullen, M.H. Chen, J.H. Hubbell, S.T. Perkins, E.F. Plechaty, J.A. Rathkopf and J.H. Scofield, "Tables and Graphs of Photon-Interaction Cross Sections from 10 eV to 100 GeV Derived from the LLNL Evaluated Photon Data Library (EPDL)," Lawrence Livermore National Laboratory Report UCRL-50400, Vol.6, Part B, Rev. 4. October 31, 1989.

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